



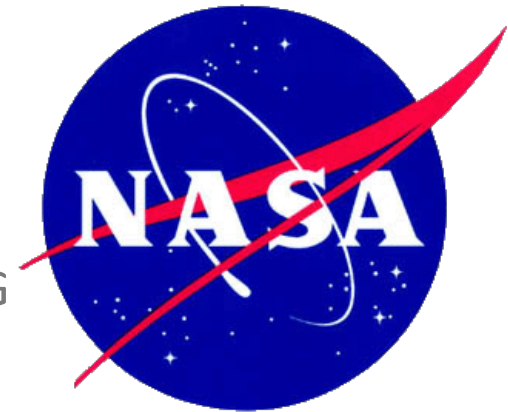
Cooperative Institute for Climate and Satellites–North Carolina
Inspire. Advance. Engage.

Kelvin Waves and Tropical Cyclogenesis in a Lagrangian Framework

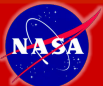


Carl Schreck

NASA PMM Grant NNX13AH47G



cicsnc.org
ncsu.edu
ncei.noaa.gov

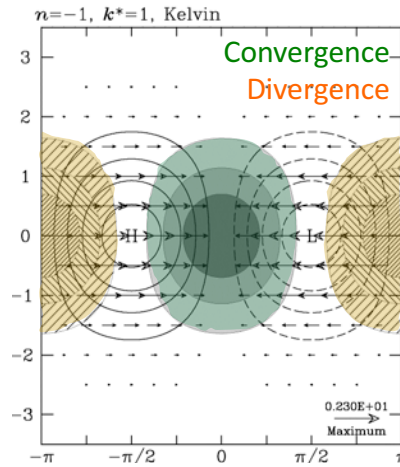


NASA PMM Science Meeting
October 2016, Houston, TX
NASA PMM Grant NNX13AH47G

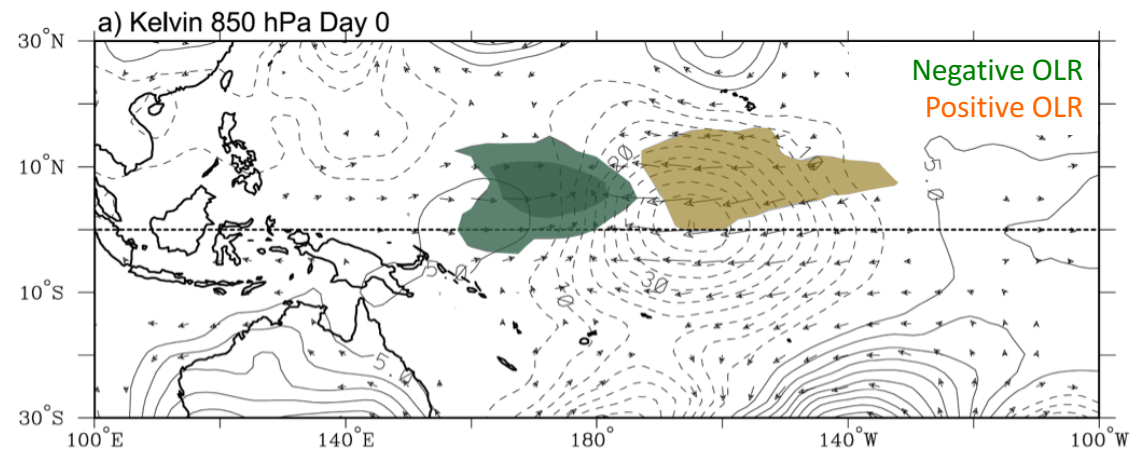
NC STATE UNIVERSITY

Background Vertical Horizontal Summary

Kelvin Waves



Matsuno (1966)



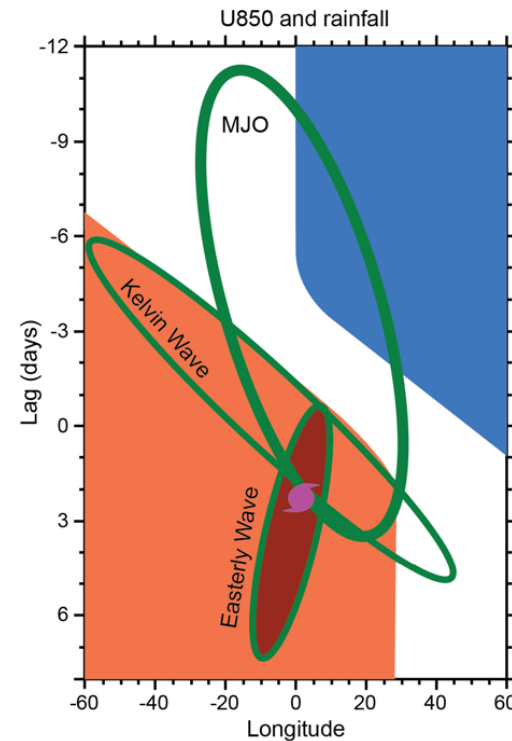
Kiladis et al. (2009)

- Alternating westerlies and easterlies on the equator
- Enhanced convection where low-level winds converge

Propagation:	Eastward
Phase speed:	10–20 m s ⁻¹
Period:	3–10 days
Wavelength:	2000–4000 km

Kelvin Waves and Tropical Cyclogenesis

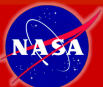
- Storms typically form 0–3 days after the Kelvin wave's convective peak
- Often interacting with MJO and Easterly Waves during genesis
- Easterly wave initiates or amplifies in the Kelvin wave convective envelope



Schreck (2015, MWR)



cicsnc.org
ncsu.edu
ncei.noaa.gov

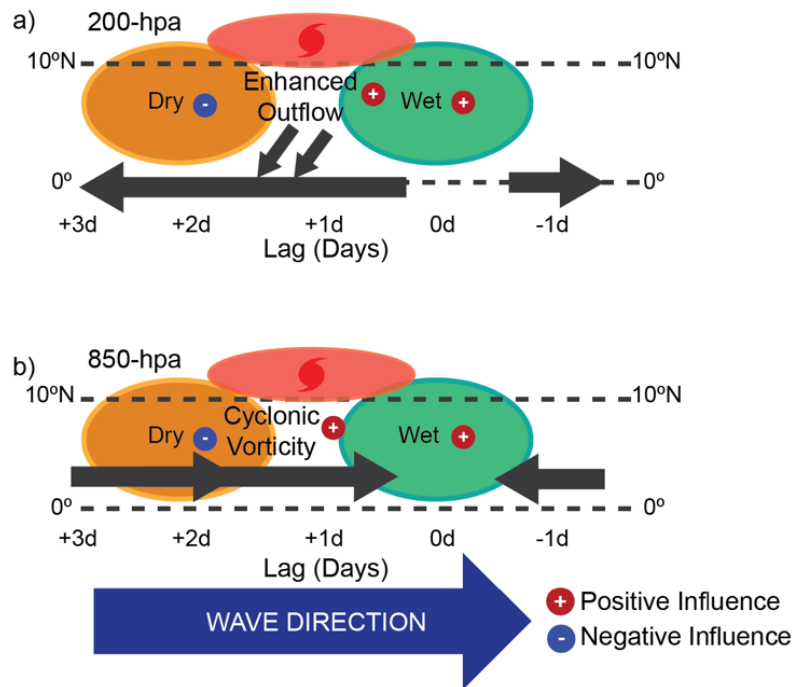


NASA PMM Science Meeting
October 2016, Houston, TX
NASA PMM Grant NNX13AH47G

NC STATE UNIVERSITY

Background Vertical Horizontal Summary

Effects on Genesis



Schreck (2015, MWR)

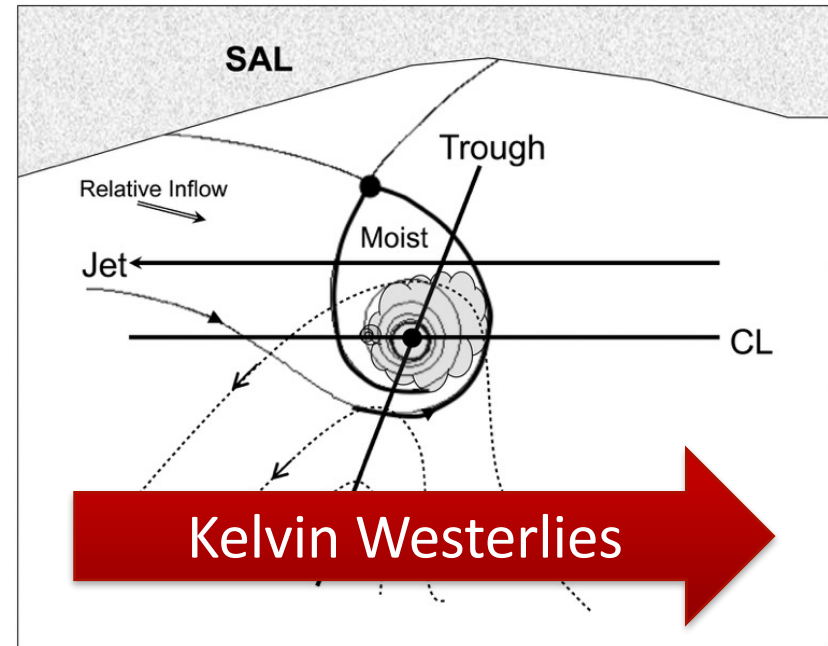
- Kelvin waves modulate key ingredients for genesis
 - Low-level vorticity
 - Convection
 - Vertical Shear
- Kelvin winds persist after the convection becomes suppressed

Kelvin Waves and Pouches

Given that Kelvin waves often interact with Easterly Waves in genesis...

Could the Kelvin waves be playing a role in closing the Easterly Waves semi-Lagrangian Circulation?

Subtracting the Easterly wave's phase speed from the zonal winds provides a wave-relative frame of reference



Schematic of an easterly wave's pouch. Adapted from Wang et al. 2010, J. Atmos. Sci., 67, 1711-1729).



cicsnc.org
ncsu.edu
ncei.noaa.gov



NASA PMM Science Meeting
October 2016, Houston, TX
NASA PMM Grant NNX13AH47G

NC STATE UNIVERSITY

Background

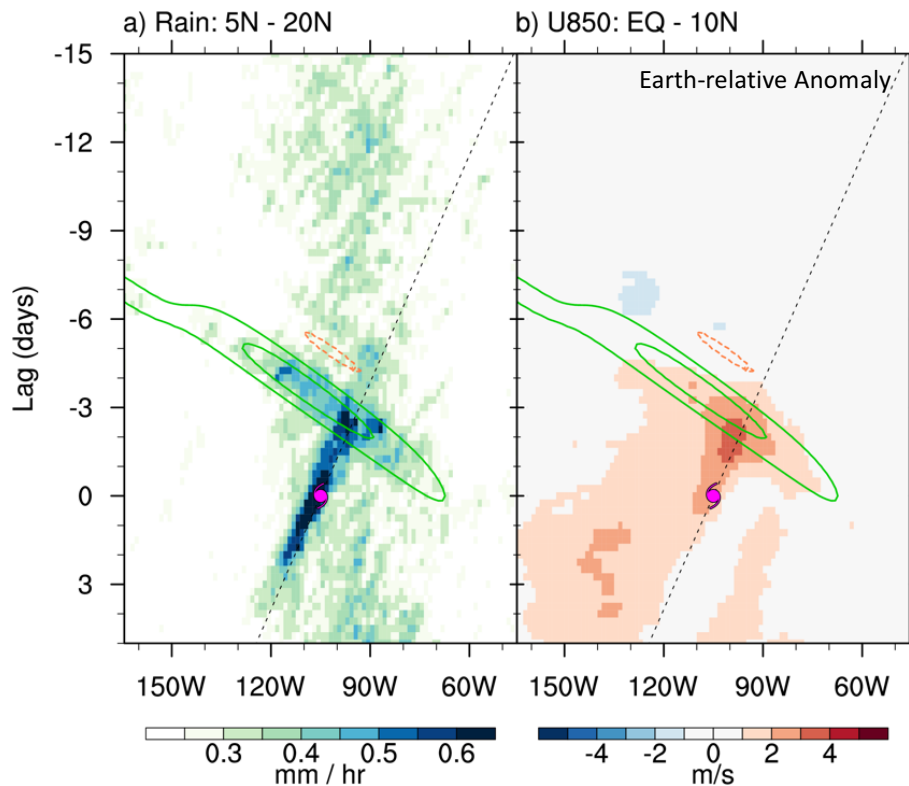
Vertical

Horizontal

Summary

Estimating Phase Speed

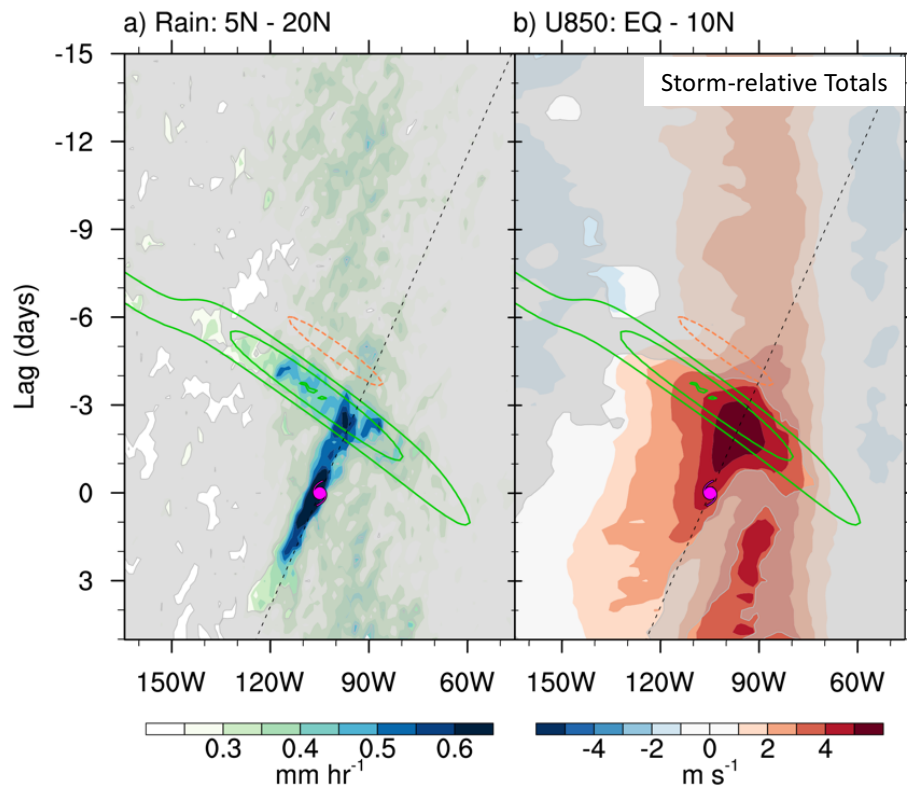
East Pacific: 40 storms



- Composite Hovmöllers of storms forming at the most favorable lags from Kelvin wave crest
- Estimate 5-m s^{-1} phase speed from these composites
- Examine semi-Lagrangian evolution by subtracting this speed from composite zonal winds

Estimating Phase Speed

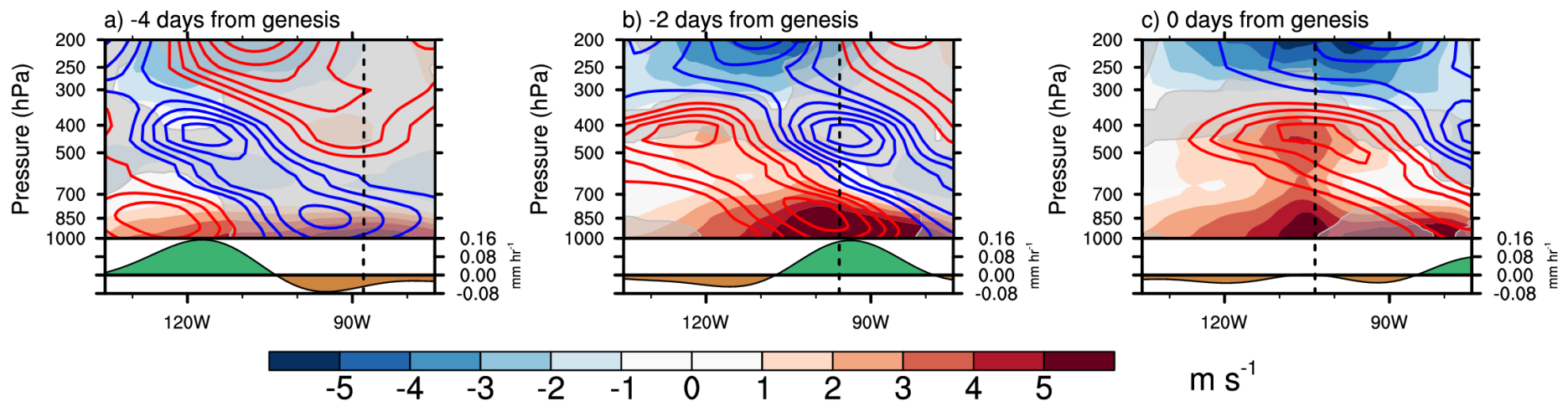
East Pacific: 40 storms



- Composite Hovmöllers of storms forming at the most favorable lags from Kelvin wave crest
- Estimate 5-m s⁻¹ phase speed from these composites
- Examine semi-Lagrangian evolution by subtracting this speed from composite zonal winds

Vertical Structure

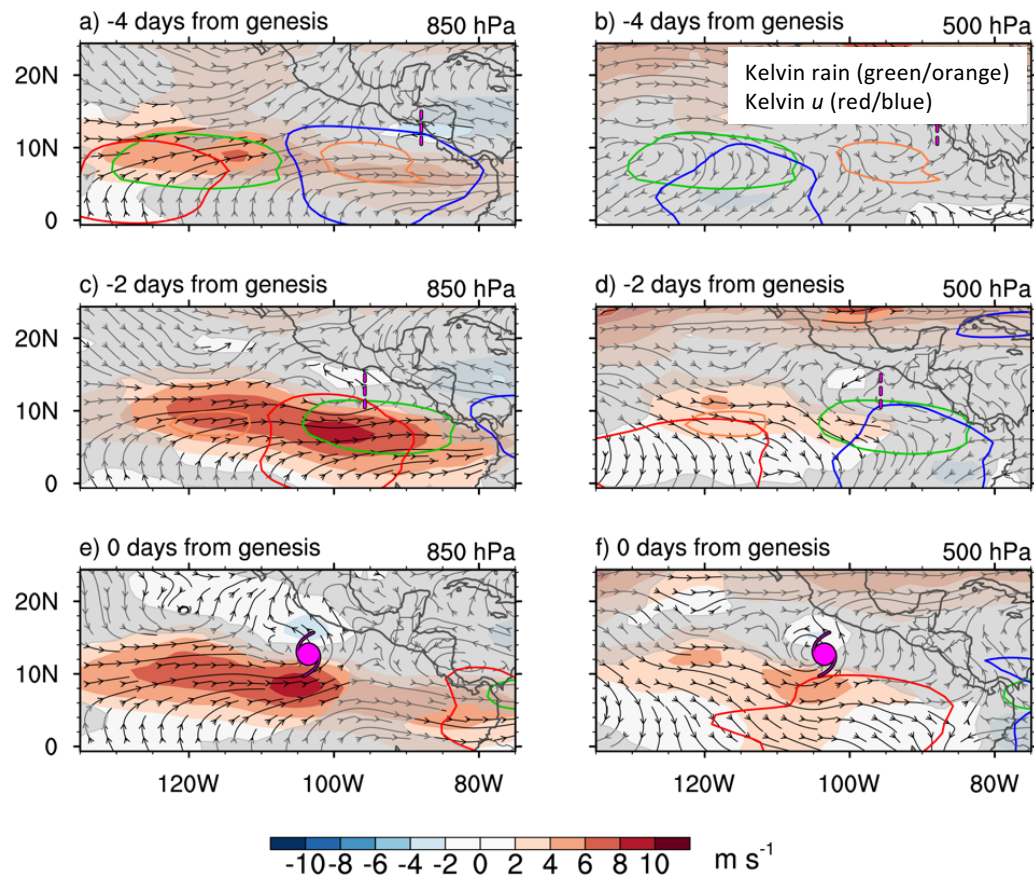
East Pacific Zonal Wind Eq-10°N



- Convection and storm-relative westerlies intersect easterly wave 2 days before genesis
- Easterly wave circulation builds upward as the Kelvin wave propagates
- Kelvin tilt might explain lag in genesis from convection
 - 400-hPa is 30° longitude behind 850-hPa
 - Kelvin speed of 15 m s⁻¹ gives a 2.5-day lag between 850 hPa and 400 hPa

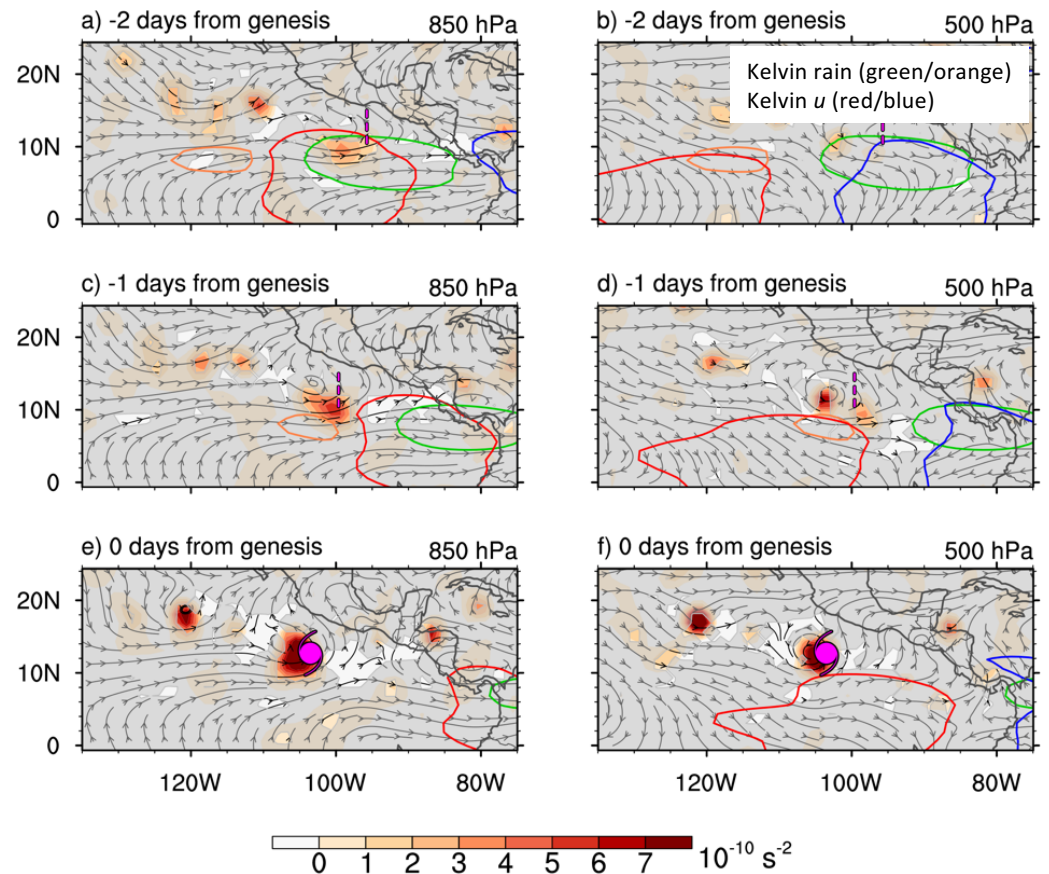
Storm-Relative Zonal Winds

- Broad, persistent 850-hPa Westerlies
- 400-hPa westerlies develop with Kelvin wave
- 2 Days before Genesis
 - Kelvin wave enhances 850-hPa westerlies and rain
 - Kelvin easterlies at 400-hPa counter Easterly wave
- At Genesis:
 - Kelvin wave no longer effects 850-hPa winds or rainfall
 - At 400-hPa, Kelvin wave helps close circulation

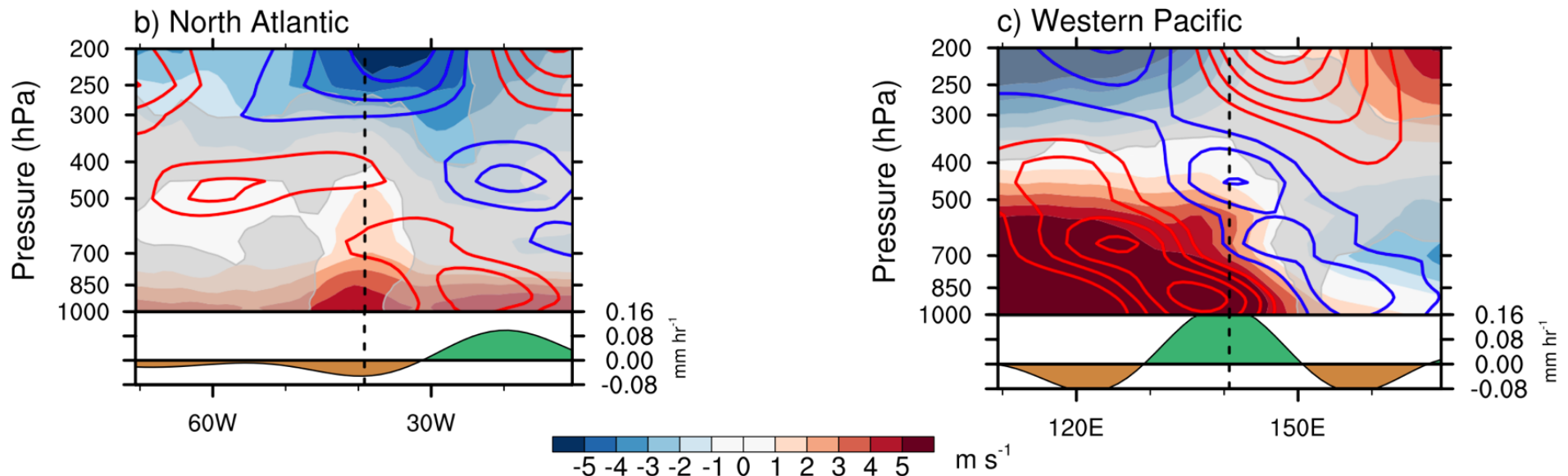


Okubo–Weiss Parameter

- Frame-independent measure of circulation
- Positive values first appear at 850-hPa when intersecting with the Kelvin wave 2 days before genesis
- 400-hPa positive values develop as the Kelvin wave approaches 1 day before genesis



Other Basins

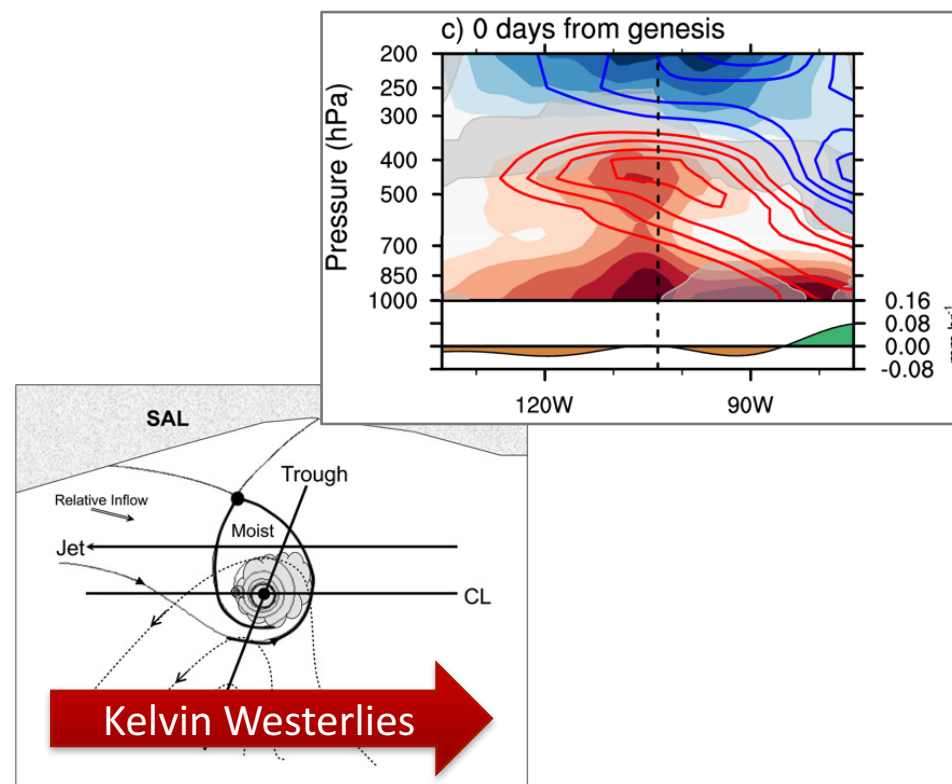


- Atlantic is similar to Eastern Pacific, but the Kelvin waves are weaker
- Western Pacific storms develop near the monsoon confluence point of the low-level winds

Summary

- Vertical tilt of Kelvin waves may explain lag between convection and genesis
 - Kelvin waves tilt westward with height
 - Cyclogenesis happens when Kelvin westerlies reach 400 hPa
- Semi-Lagrangian framework shows Kelvin westerlies developing the easterly wave circulation upward

Schreck, C. J., 2016: Convectively Coupled Kelvin Waves and Tropical Cyclogenesis in a Semi-Lagrangian Framework. *Mon. Wea. Rev.*, **144**, 4131–4139, doi:10.1175/MWR-D-16-0237.1.



Schematic of an easterly wave's pouch. Adapted from Wang et al. 2010, J. Atmos. Sci., 67, 1711-1729).

Future Work

- Why do easterly waves amplify at Kelvin intersection?
 - Low-level vorticity?
 - Low-level shear?
 - Moisture?
 - Surface fluxes?
 - Nonlinear interaction?
- Much depends on rapid evolution of surface winds, so CYGNSS data will be valuable

